Lab Assignment 1:

Tolerance Assigning, Machining and Testing of a Two-Part Assembly

COLLEGE OF SCIENCE AND ENGINEERING

Manufacturing Processes

ENGR 3350-001

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Executive Summary

ABSTRACT

This lab report will break ~~down~~ into detail the procedure taken to develop the plate and shaft two part assembly. Explanations and figures will aid in the rendition of the report. This experiment improved the understanding of machining, tolerances, and the expectations of co-working machinists in future work. The purpose of this experiment was to create a two part aluminum plate and shaft made from Aluminum 6061 - T6511 that can withstand 10 ft.-lb_f torque applied to the end of the shaft without inducing relative motion. To complete this objective, and interference fit between the shaft and plate with precise tolerances would have to be met so that the two part system would complete the task.

details

assembly with two part

systems

Introduction

become

The aim of this lab experiment was to ~~get~~ familiar with machining tolerances, gain a better understanding for material performance, and to develop a respect for the art of machining. To achieve the desired results, the team created a two ~~part~~ parts assembly that included an aluminum plate and an aluminum shaft. This assembly had to be machined to specific tolerances. The plate needed the center hole to be within a tolerance of +0.8 thousandths of an inch and and 0.0 thousandths of an inch. The shaft had to be within +1.9 thousandths of an inch and + 1.4 thousandths of an inch. The shaft was threaded using a tap so that a screw could be inserted full length without damaging the threads. The shaft was notched to pass a 10 ft.lb_f torque test. It should be noted that the torque test was actually closer to 12 ft.lb_f. The aluminum plate was also out of spec due to the factory dimensions not equal to the 3.00 inches.

Aluminum is the proper name of an element

within

(h7 S6 ?)

?

what does a notch have to do ~~this~~ with a torque test?

?

THEORY

The main concept used in this experiment is the machining of the plate and shaft, and measuring the material removal rate per unit of time. Material was removed by drilling, using the milling machine mill to face the plate, and bring the plate and shaft to the right dimensions, and the lathe shaped and removed the material needed for the shaft. Would be better placed w/ lathe work

(?) ← equation #

Drilling $$MRR = (\frac{\pi D^2}{4}) f N$$ → what is this? what is the name and function of this equation?

Where:

D is diameter of the hole

f is feed rate, the distance the drill penetrates per unit revolution

N is the rotational speed of the drill

Turning MRR =

Where is the first application?

Another application of Material Removal Rate (MRR) would be when face milling which occurred when the base plate was milled to correct specifications. The equation is then based on the speed the material is fed to the machine and the cross section that the milling tool is working on. sections

$$MRR = w\, d_c\, V$$

(?) equation #

Where:

w is width of work

d_c is depth of cut

V is linear speed of the workpiece

V = ?

list these and explain in the list of nomenclature.

The shaft and plate are pressed together and are held by an interference fit standard of H7-s6. ~~An interference fit is made when the external dimension of the fit, in this case the shaft, is~~

~~larger than the dimension for the inside plate.~~ hole ~~This type of fit allows for friction to hold the two pieces together.~~

This interference fit is made within a certain tolerance range such that the assembly can withstand the applied torque. The equation used to calculate the tolerance is shown on the next page. ?

interference

what is this?

$$P=\frac{\delta}{\frac{d}{Eo}\left(\frac{do^2+d^2}{do^2-d^2}+\gamma\right)+\frac{d}{Ei}\left(\frac{d^2+di^2}{d^2-di^2}-\gamma\right)}$$

(?) equation #

Where:

P is pressure

E is the Modulus of Elasticity

γ is Poison's ratio

d_o is the diameter between each of the outsetting holes

d_i is the inside diameter of the hole

d is the diameter of the center hole

Eo?

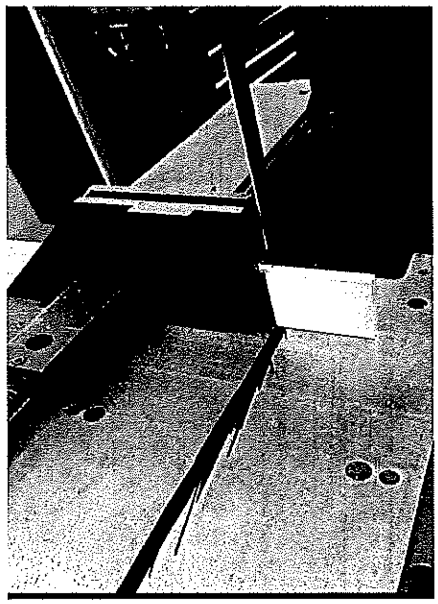
Ei?

δ = ?

EQUIPMENT

The two pieces of material were cut using a bandsaw. The bandsaw has one blade moving up and down vertically at a desired speed and feed rate. These large teeth are not ideal for a nice finish surface, therefore excess material was left on to shave off with the milling machine.

FIGURE (1): Bandsaw cuts the first piece of material off of the stock bar.



After the rough cut, a milling machine was used to give the plate the correct dimensions and an ideal finish surface.The milling machine has a vise to hold the material in place. The machine also has several cranks to adjust the piece in the x, y, or z direction. For the material removal a three insert fly cutter was used. This 3-piece cutter has removable teeth made of tungsten carbide which make this tool overall durable and simple to replace teeth.

(2) (3)

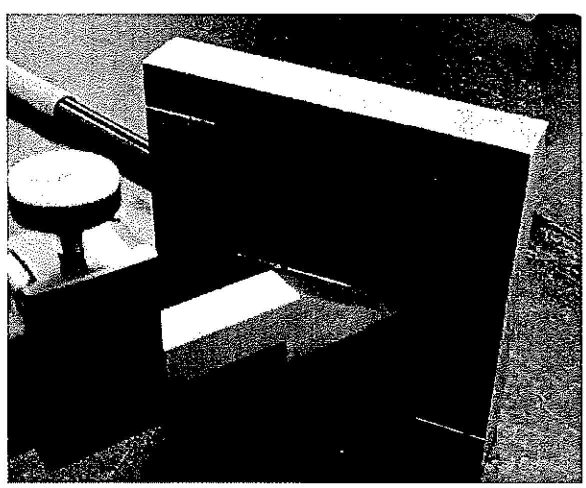
FIGURE (2): The milling machine drilling out the middle hole for the shaft.

FIGURE (3): The fly cutter making passes on the base plate.

vertically

For the next procedure, the plate needed to be marked for the correct holes. A scribe was used to mark a painted surface. The scribe is accurate to a thousandth of an inch. Scribing is a technique used to carry a line across material, often intersecting another line to make a point.

FIGURE (4): The scribe scratching marks on the material to mark the holes.



To drill the marked holes, the milling machine was used with three different drill bits. The center bit that was used to make a small pilot hole. Using the same coordinates the center bit was drilled at, the 0.375" drill bit was then used to finish with the ideal hole size. The center hole was drilled using the same technique.

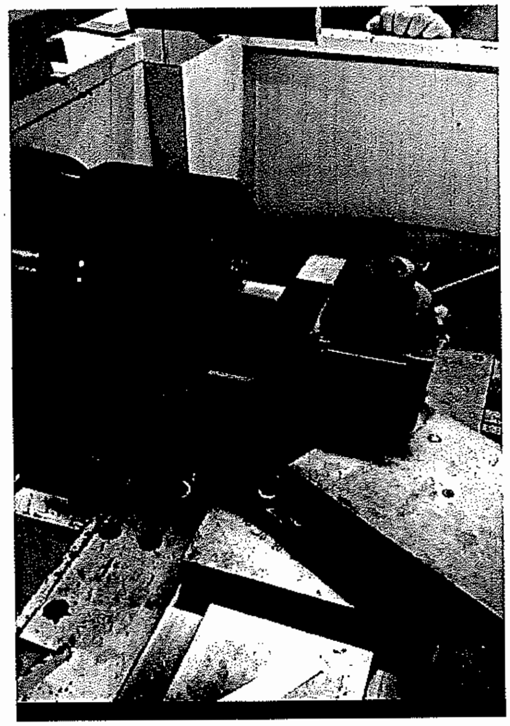
(5) (6)

FIGURE (5): The 0.75" drill bit following the same pilot hole procedure.

FIGURE (6): The milling machine drilling out the marked hole the center bit left with .375" drill bit..

A lathe is a machine that removes material with a different approach. Most of the machines hold the material stationary and move the tools to make the cut. The lathe holds the tool stationary and the material is rotated at the desired speed. According to the adjusted ~~tool~~ the piece may be tapered, drilled, tapped, and even faced off.

FIGURE (7): The lathe cleaning the initial rough cut made with the bandsaw.



The 20 22 ton hydraulic press was used to press fit the plate and shaft assembly together. The one pictured was off centered enough to where the team had to use the bleed valve to bleed the pressure and turned turn the shaft. With small steps of compression and rotation the two part assembly was press fit together symmetrically.

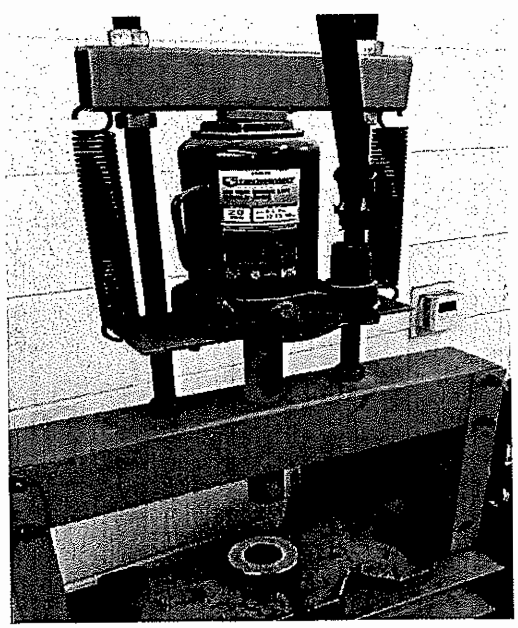
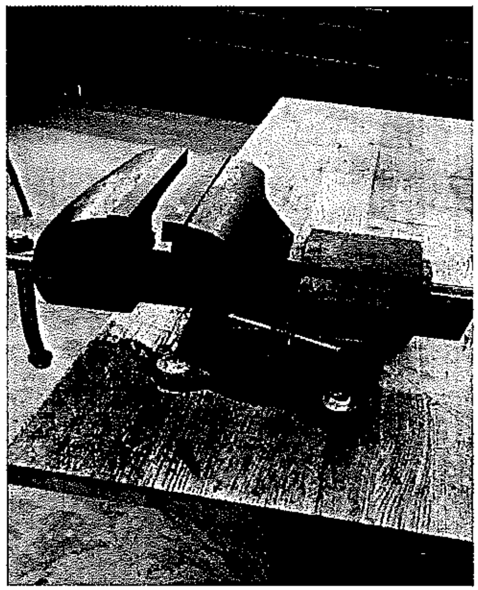


FIGURE (8): The 20 22 ton hydraulic press which was used to press fit the two part assembly.

A vise was used for several parts of the experiment as well as testing. The handle is rotated till the jaws have the desired grip on the material. Once the material was in place ,the rough surfaces were made smooth with the file. Then the piece could be torque tested with the vise holding the base plate.

FIGURE (9): The vise responsible for holding the material to ensure general hand safety.



A flat file as seen in figure (10) was used to take care of the some of the rough cleaning on the plate before milling. It was also used to do touch up where a burr of metal was still attached. The flat file was also used to knurl the shaft which would make the interference fit less difficult.

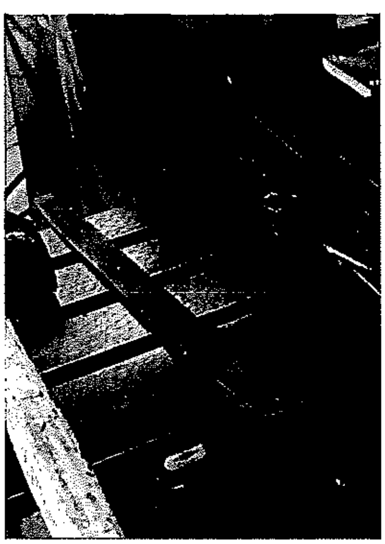


FIGURE (10): The flat file that was used to deburr the material and knurl the shaft.

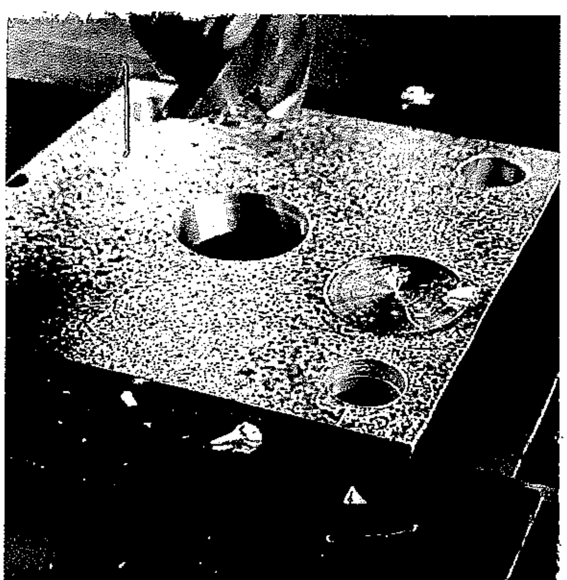
Procedure

For the first part of the experiment the team cut the 3" square x1/2" thick plate using the bandsaw. the kerf of the bandsaw was ⅛ in inch ~~thick~~. To allow for the blade kerf the plate was cut to a length of 3.130" which means 0.130" of material was left on to account for possible error and inaccuracy. The team marked 3.125" on the plate and after cutting with the bandsaw arrived at 3.130". A flat file was then used to remove the large burs that were left on the side that was cut. The shaft was also cut with the bandsaw. Accounting for the kerf of the bandsaw again the shaft was cut to 2.625" in length.

The mill was used to cut down the remaining material off of the plate to get the plate ~~down~~ to the proper dimensions within the tolerance. The plate was placed on the vise with the unfinished side facing upwards towards the fly cutter mill. A feeler gauge was placed on top of the plate as the fly cutter was the bed of the milling machine is raised lowered towards it. The feeler gauge was then moved back and forth till one of the inserts teeth on the fly cutter grabbed it. Then the "zero" could be set. The "zero" is where the depth of cut is referenced from. Adjusting the z-coordinate 20 thousands would be cutting into the face of the material 20 thousandths. Taking this into account, the team started with passes of 0.020". Due to the tool performance there was slight variation in the amount intended to cut and the amount that was taken off. Once the material piece arrived towards specified dimensions ~~tolerance~~ the increments were decreased to 0.010" and even 0.005" at a time. The mill was turning the fly insert at 200 rpm.

Do not provide this much detail.

Once the plate was finished and to proper size the fly cutter was taken out of the mill T the plate was covered lightly in paint to help mark the hole centers. Since the plate is not made to perfect dimensions the holes were calculated based on the distance of the hole from the edge of the plate. A scribe tool was then used to cut into the paint and mark the centers of each of the holes. ~~Then and~~ a drill chuck was installed to start the drilling process. The technique performed was a square around the plate using one of the x, y, and z coordinates as a guide for the next hole. Unclear the The first hole was made using the center bit on the marked corner of the plate in the center of the intersecting lines. Once the center bit drilled around 0.125" deep the center bit was removed and the 0.375" drill bit was inserted and the hole was drilled all the way through the plate. The drill bit was removed and replaced ~~again~~ with the center bit. Careful to keep the x axis fixed the next hole was made using by moving the center bit along the y axis 2.25". The center bit was used to make the initial depression hole and then the 0.375" drill bit completed the hole. The same process was used for the remaining two holes using a fixed axis guide for uniform accuracy. The final hole was produced using a face mill technique and an end mill ~~a bit~~ with a external diameter of around 0.75". The hole was made by pressing down onto the aluminium and removed material then released to ease the temperature and overall stress on the inserts. When the hole was made there was a remaining ??



?

FIGURE (11): The coupon is compared to the size of the hole cut with the .75" ~~drill bit~~ end mill.

Three different measurements were made ~~along~~ of the ~~inside~~ diameter of the center hole ~~and~~ with an average ~~was taken~~ of about 0.757"; Therefore, ~~so~~ the shaft needed to be cut down to a diameter of about 0.764". 0.007" interference? Why so much? The shaft was cut down using the lathe from the initial length of 2.613" to 2.510" using 0.02" pass every time until the shaft got to around 2.521 ? 2.521" then depths of 0.005" were used until the proper length was met. One end of the shaft needed to have a diameter of around 0.764" in order to be within the tolerance of the interference fit. The shaft was measured 0.5" from the end ~~of the shaft~~ and was marked from with? pencil. The lathe was brought ~~right~~ up to the line and a fine cut was made towards the end of the shaft. A measurement of 0.972" was taken after the first pass and that was made our "zero". From there the shaft was cut at ~~increments~~ depths of around 0.02" until the Ø reached 0.792" then a finer increment of 0.005" was used until a final diameter of 0.763" was made. Then while on the lathe the hole in the middle of the shaft was made using a .25" drill bit and drilling a hole 0.75" deep. Our team drilled into the shaft about 1.00". The whole was then threaded with a set of three taps ranging from a fine tip to a very blunt end. The inner hole was threaded around 0.75" deep. ~~Finally~~ both ends of the shaft were chamfered with a file. The lathe was set to run at 400 rpm. this goes earlier

Once both parts were finished, the shaft and plate are pressed into each other with a 20 ton hydraulic press shown in Figure 8. Finally the shaft was placed back onto the mill to have the front end of the shaft notched ~~off~~ for testing. The shaft was notched from the top 0.156" deep and 0.625" along the shaft from the front end.

Data

Table 1. Measurements of Aluminum Stock		
	Theoretical (in.)	Actual (in.)
Side 1	3.00	2.993
Side 2	3.00	2.999
Side 3	3.00	2.993
Side 4	3.00	3.000

Table 1. This table contains the theoretical and actual measurements for the aluminum stock. These values were measured using the 6" caliper.

Table 2. Diameters of Drill Holes in Aluminum Stock		
	Theoretical (in.)	Actual (in.)
Corner Hole 1	0.375	0.375
Corner Hole 2	0.375	0.377
Corner Hole 3	0.375	0.372
Corner Hole 4	0.375	0.374
Center Hole	0.75	0.757

Table 2. This table contains the theoretical and actual measurements for the center and corner holes drilled into the aluminum stock. These values were measured using a 6" caliper.

Table 3. Measurements of Aluminum Shaft		
	Design (in.)	Actual (in.)
Total Length Shaft	2.50	2.510
Length Insert	0.50	0.485
Larger Diameter	1.00	0.998
Smaller Diameter	0.75	0.763

Table 3. This table contains the actual and theoretical measurements for the lengths and diameters of the shaft. These values were measured using the 6" caliper.

Results

For the testing of the two part assembly a 10 ft.lb$_f$ torque was applied to the shaft. To pass the test the part may not induce relative motion. torque After the piece was notched and pressed into the plate, the torque testing kit was attached to the assembly. The bar was attached to the shaft at the notch and the final hole on the end of the bar is 12" from the shaft. Then the weight was slowly added on so that it would not produce any unnecessary jerks on the assembly.

FIGURE (12): The two piece assembly holds steady as it is torque tested.

As shown in figure 12, the shaft did not induce relative movement therefore passing the test. Another small test included in the experiment was to successfully tap the shaft and have a screw rotate full length into the shaft. The test was also a success as shown in figure 13.

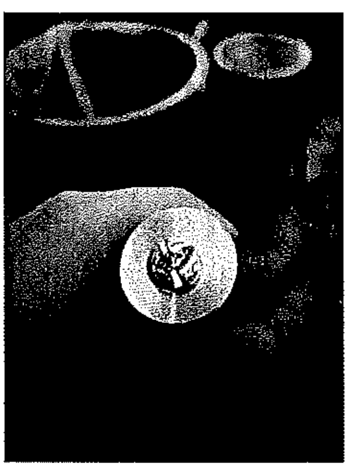
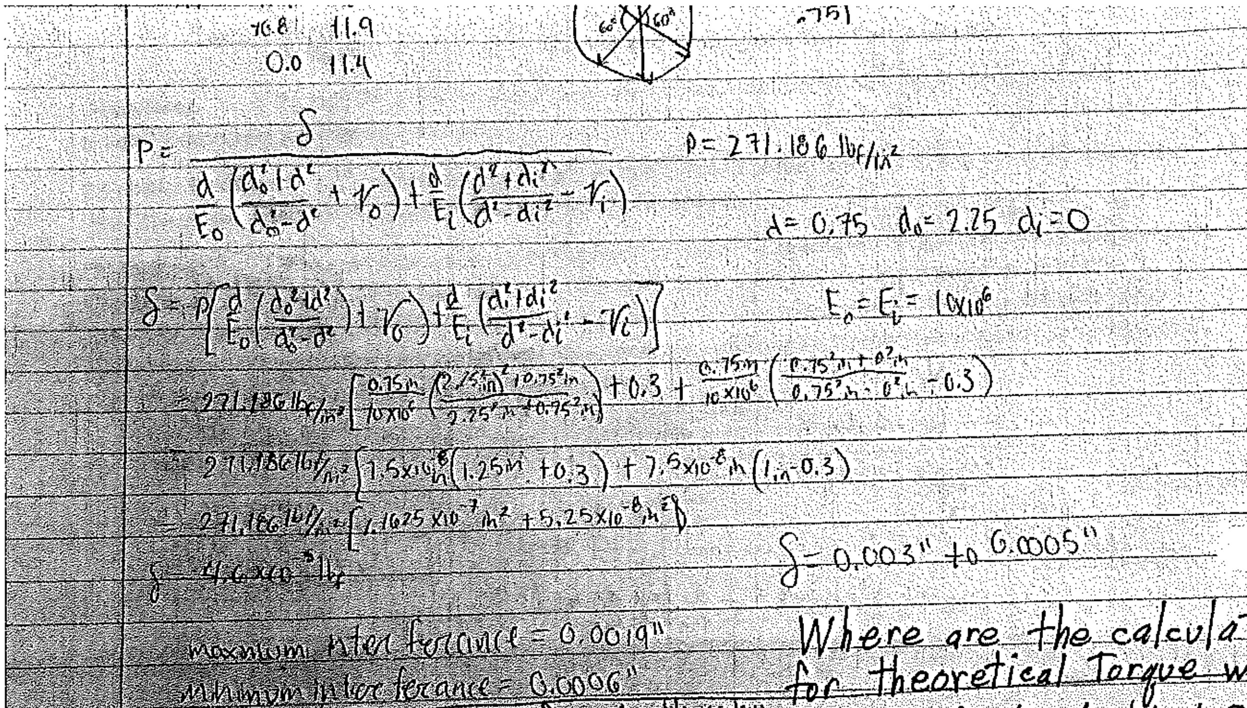


FIGURE (13): The screw fit into the tapped shaft with ease showing that the threads were well made.

Summary

The purpose of this lab was to fabricate a two-piece aluminum shaft and plate assembly with the proper calculated tolerances to withstand the 10 ft.-lb_f of torque without producing relative motion. The plate was bolted to a bracket to ensure the holes were measured properly and a 12" arm was connected to the shaft with a mass hanger. The actual torque applied was closer to 12 ft.-lb_f. When the aforementioned torque was applied, the assembly did not experience relative motion; therefore, the experiment was successful.

A. Calculations



Where are the calculations for theoretical Torque with the specified and actual δ?

Figure (14): Sample calculation of the tolerance needed for the interference fit of the assembly.

B. List of Nomenclature

Most of these are definitions

Material Removal Rate (MRR) - explain what this is

burr - an unwanted rough piece on the material that is usually filed off this is not nomenclature

chamfer - is to cut the edge of the material at a downward angle

feeler gauge - a small piece of material roughly 3 thousands thick used to “zero” tools

ideal finish surface - shiny smooth surface with no defections were the tool changed the pattern

interference fit - where a larger diameter shaft is forced into a smaller diameter hole

kerf - width of the blade

knurl - produce regularly shaped roughness on cylindrical surfaces

tap - used to create screw threads on the inside of material

tolerance - the plus or minus the dimensions are allowed to vary

C. List of Figures

Include the lab drawing.

should not be here

D. Annotated Bibliography

[1] Kalpakjian, S. and Schmid, S., 2013, *Manufacturing Engineering and Technology*, 7th ed., Pearson, Upper Saddle River, NJ